

WHAT IS CLAIMED IS:

1. A photoalignable top-sealing composition for top-sealing and aligning a liquid crystal (LC) composition filled in a top-opened display cell, which photoalignable top-sealing composition is alignable by a polarized light.

5 2. The composition of Claim 1 which comprises a photoalignable polymer, oligomer or a precursor thereof dissolved or dispersed in a sealing solvent or solvent mixture.

3. The composition of Claim 2 which has a specific gravity no greater than that of the LC composition and is immiscible with the LC composition.

10 4. The composition of Claim 2 wherein said photoalignable polymer, oligomer or a precursor thereof comprises a photoalignable functional group on the main chain or a side chain.

15 5. The composition of Claim 2 wherein said photoalignable polymer, oligomer or a precursor thereof comprises a hydrocarbon repeating unit and a photoalignable functional group on the main chain or a side chain.

6. The composition of Claim 2 wherein said photoalignable polymer, oligomer or a precursor thereof comprises a siloxane repeating unit and a photoalignable functional group on the main chain or a side chain.

20 7. The composition of Claim 2 wherein said photoalignable polymer, oligomer or a precursor thereof comprises an acrylate, methacrylate or vinyl repeating unit and a photoalignable functional group on the main chain or a side chain.

25 8. The composition of Claim 2 wherein said photoalignable condensation polymer or oligomer comprises a repeating unit such as a condensate of urethane, urea, carbonate, ester, amide, sulfone, imide, epoxide or formaldehyde and a photoalignable functional group on the main chain or a side chain.

9. The composition of Claim 2 which comprises a random copolymer, a graft copolymer, a branch copolymer or a block copolymer having a photoalignable group in the main chain or a side chain.

10. The composition of Claim 2 which comprises a block copolymer with at 5 least one photoalignable block having a photoalignable functional group on the main chain or a side chain and another block(s) that is/are compatible with the sealing solvent or other non-photoalignment polymers, if present, in the top-sealing composition.

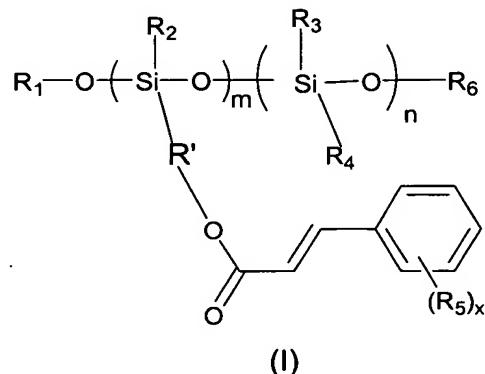
11. The composition of Claim 2 which comprises a graft copolymer having 10 at least one photoalignable graft chain and a main chain that is compatible with the sealing solvent or other non-photoalignable polymers, if present, in the top-sealing composition.

12. The composition of Claim 2 which comprises a precursor of a photoalignable polymer or oligomer.

13. The composition of Claim 4 wherein said functional group is selected 15 from the group consisting of cinnamate, coumarin, chalcony, benzolidenenaphthalidine, benzylideneacetophenone, diphenylacetylene, stilbazole, stilbene, diphenylacetylene, diazo and spiropyran.

14. The composition of Claim 2 wherein said photoalignable polymer, 20 oligomer or a precursor thereof is selected from the group consisting of the following:

Formula I

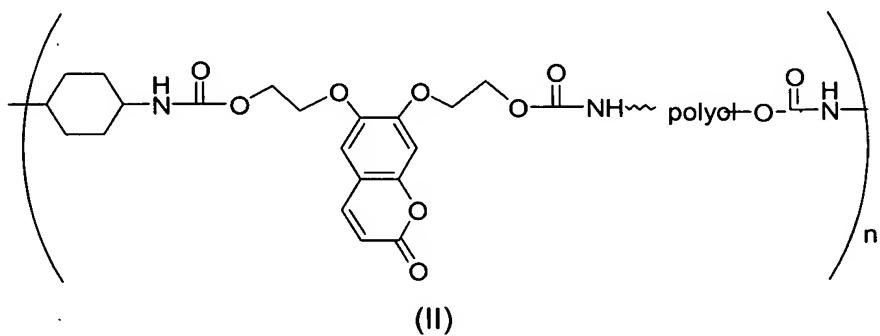


wherein x is an integer of 1-5;

m and n are integers and their sum is ≥ 20 , preferably ≥ 50 ,
 R_1, R_2, R_3, R_4 and R_5 are independently alkyl, aryl, alkylaryl or their heteroatom derivatives thereof, preferably having 1-12 carbon atoms, substituted or unsubstituted alkylsilyl derivatives; and

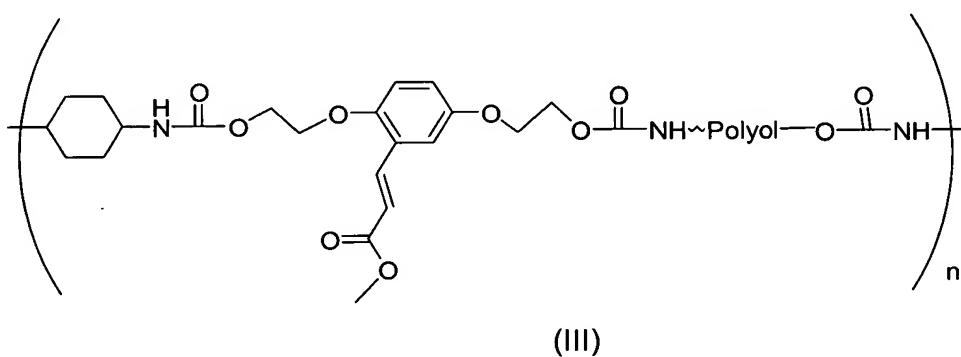
5 R' is a linking group such as alkylene, cycloalkylene or phenylene;

Formula II



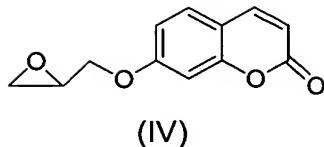
10 wherein n is integer ≥ 1 ; and the polyol moiety is formed from polyethylene glycol, polypropylene glycol, poly tetramethylene glycol, polyester diol, polyalkylene diol or a fluorinated polyether diol;

15 **Formula III**

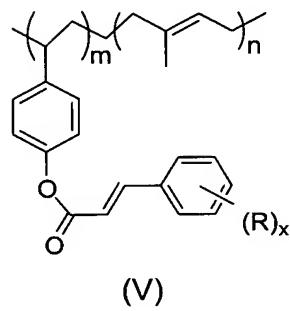


20 wherein n is an integer ≥ 1 ; and the polyol moiety is formed from polyethylene glycol, polypropylene glycol, poly tetramethylene glycol, polyester diol, polyalkylene diol or a fluorinated polyether diol;

Formula IV



Formula V



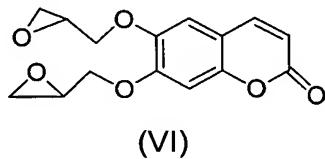
5 wherein x is an integer from 0 to 5;

m and n are integers and their sum is ≥ 30 ; and

R is alkyl, aryl, alkylaryl, alkoxy, aryloxy, dialkylamino, diarylamino or cyano,

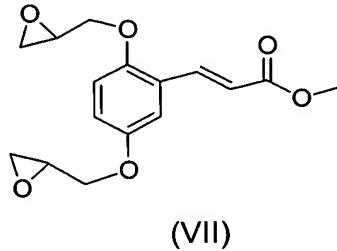
10 preferably having 1-12 carbon atoms;

Formula VI



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Formula VII



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15. The composition of Claim 2 wherein said sealing solvent or solvent mixture has a specific gravity no greater than the liquid crystal composition and is immiscible with the liquid crystal composition.

16. The composition of Claim 15 wherein said sealing solvent or solvent mixture is selected from a group consisting of straight, branched or cyclic C₁₋₁₂ hydrocarbons, C₁₋₄ alcohols, water and mixtures thereof.

17. The composition of Claim 16 wherein said hydrocarbon solvent is
5 selected from the group consisting of hexane, cyclohexane, heptane, octane, nonane, decane and decalin.

18. The composition of Claim 16 wherein said alcohol is methanol, ethanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol or t-butanol.

19. The composition of Claim 2 wherein the concentration of said
10 photoalignable polymer, oligomer or a precursor thereof in the sealing solvent or solvent mixture is in the range of about 3 to about 25% by weight.

20. The composition of Claim 19 wherein the concentration of said photoalignable polymer, oligomer or a precursor thereof in the sealing solvent or solvent mixture is in the range of about 5 to about 15% by weight.

15 21. The composition of Claim 2 further comprising a non-photoalignable polymer.

22. The composition of Claim 21 wherein said non-photoalignable polymer is a polymeric binder or thickener.

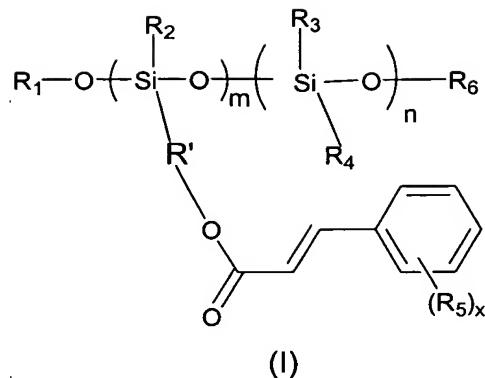
20 23. The top-sealing composition of Claim 2 further comprising a low molecular weight photoalignable dichroic compound.

24. The composition of Claim 23 wherein said photoalignable dichroic compound has a molecular weight less than about 1000.

25 25. The composition of Claim 24 wherein said photoalignable dichroic compound is selected from a group consisting of azobenzenes, stilbenes and spirobifluorans.

26. A photoalignable polymer, oligomer or a precursor thereof represented by one of the following formulas:

Formula I



wherein x is an integer of 1-5;

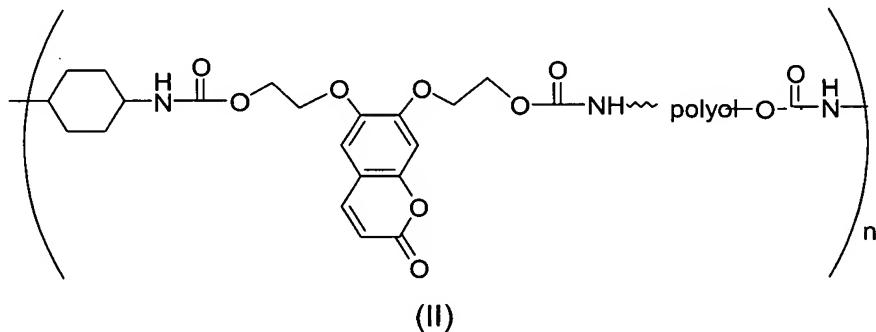
5 m and n are integers and their sum is ≥ 20 ;

R_1 , R_2 , R_3 , R_4 and R_5 are independently alkyl, aryl, alkylaryl or their heteroatom derivatives thereof, preferably having 1-12 carbon atoms, substituted or unsubstituted alkylsilyl derivatives; and

R' is a linking group such as alkylene, cycloalkylene or phenylene;

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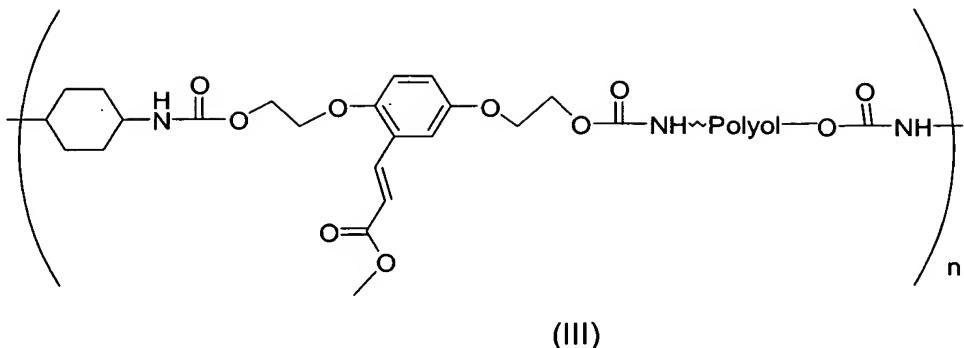
Formula II



15 wherein n is integer ≥ 1 ; and the polyol moiety is formed from polyethylene glycol, polypropylene glycol, poly tetramethylene glycol, polyester diol, polyalkylene diol or a fluorinated polyether diol;

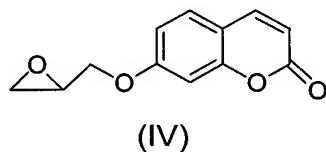
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Formula III



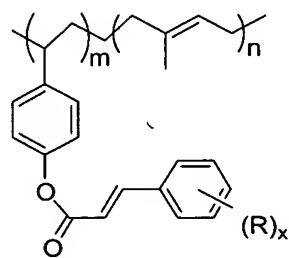
5 wherein n is an integer ≥ 1 ; and the polyol moiety is formed from polyethylene glycol, polypropylene glycol, poly tetramethylene glycol, polyester diol, polyalkylene diol or a fluorinated polyether diol;

Formula IV



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Formula V

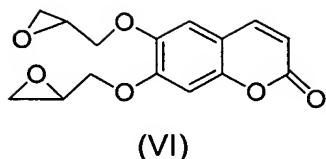


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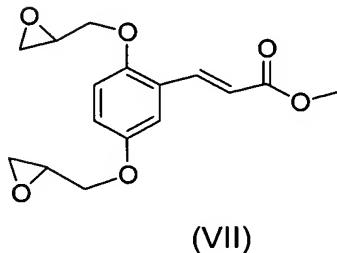
wherein x is an integer from 0 to 5;
m and n are integers and their sum is ≥ 30 ;
and R is alkyl, aryl, alkylaryl, alkoxy, aryloxy, dialkylamino, diarylamino or cyano,
preferably having 1-12 carbon atoms;

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Formula VI



5 **Formula VII**



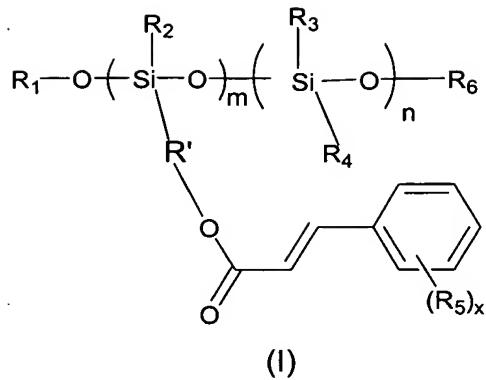
27. A process for top-sealing a display cell of a liquid crystal display which
10 process comprises predispersing a photoalignable top-sealing composition into a
liquid crystal composition, filling the predispersion into the display cell, and
simultaneously or sequentially hardening the photoalignable sealing composition
after phase separation and aligning the photoalignable sealing layer.

28. The process of Claim 27 wherein said photoalignable top-sealing
15 composition comprises a photoalignable polymer, oligomer or a precursor thereof
having a photoalignable functional group on the main chain or a side chain.

29. The process of Claim 28 wherein said photoalignable functional group
is selected from the group consisting of cinnamate, coumarin, chalcony,
benzolidenenaphthalidine, benzaylideneacetophenone, diphenylacetylene,
20 stilbazole, stilbene, diphenylacetylene, diazo and spiropyran.

30. The process of Claim 27 wherein said photoalignment top-sealing
composition comprises a photoalignable polymer, oligomer or a precursor thereof
represented by one of the following formulas:

Formula I



(I)

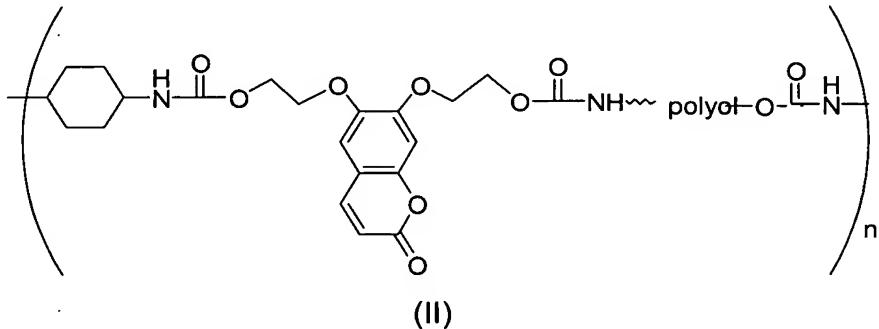
wherein x is an integer of 1-5;

5 m and n are integers and their sum is ≥ 20 ;

R₁, R₂, R₃, R₄ and R₅ are independently alkyl, aryl, alkylaryl or their heteroatom derivatives thereof, substituted or unsubstituted alkylsilyl derivatives; and

R' is a linking group such as alkylene, cycloalkylene or phenylene.

10 **Formula II**

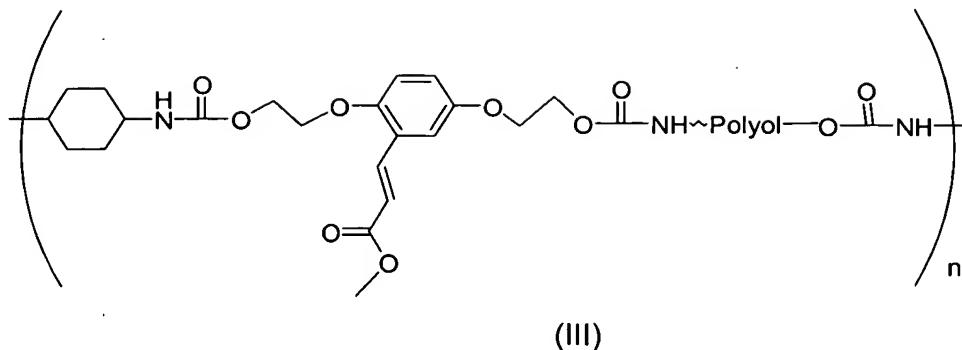


(II)

wherein n is integer ≥ 1 ; and the polyol moiety is formed from polyethylene glycol,

15 polypropylene glycol, poly tetramethylene glycol, polyester diol, polyalkylene diol or a fluorinated polyether diol;

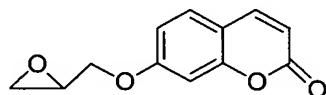
Formula III



(III)

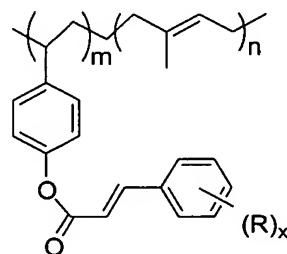
5 wherein n is an integer ≥ 1 ; and the polyol moiety is formed from polyethylene glycol, polypropylene glycol, poly tetramethylene glycol, polyester diol, polyalkylene diol or a fluorinated polyether diol;

Formula IV



10 (IV)

Formula V



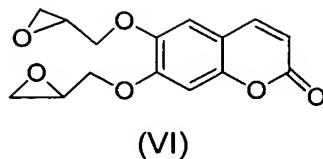
(V)

wherein x is an integer from 0 to 5;

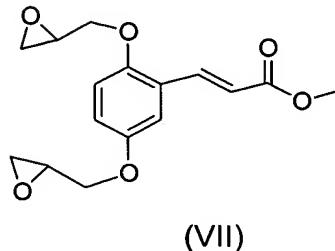
15 m and n are integers and their sum is ≥ 30 ; and

R is alkyl, aryl, alkylaryl, alkoxy, aryloxy, dialkylamino, diarylamino or cyano, preferably having 1-12 carbon atoms;

Formula VI



5 **Formula VII**



31. The process of Claim 27 wherein hardening of the photoalignable top-
10 sealing layer is accomplished by heat, moisture, solvent evaporation or exposure to
radiation.

32. The process of Claim 31 wherein said radiation is a polarized (UV)
light.

33. The process of Claim 32 wherein the polarized light exposure is carried
15 out under an electric field.

34. A process for top-sealing a display cell of a liquid crystal display which
process comprises filling a liquid crystal composition into the display cell, overcoating
a photoalignable sealing composition onto the liquid crystal layer and simultaneously
or sequentially hardening the photoalignable sealing composition and aligning the
20 photoalignable sealing layer.

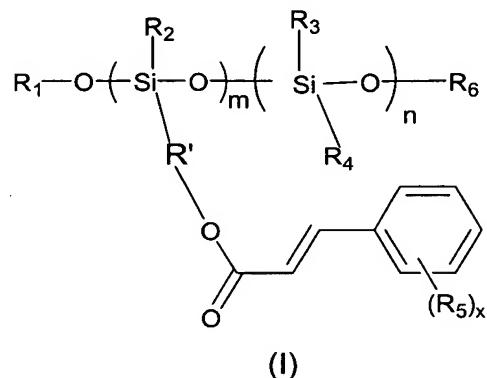
35. The process of Claim 34 wherein said photoalignable top-sealing
composition comprises a photoalignable polymer, oligomer or a precursor thereof
having photoalignable functional group on the main chain or a side chain.

36. The process of Claim 35 wherein said photoalignable functional group
25 is selected from the group consisting of cinnamate, coumarin, chalcony,

benzolidenenaphthalidine, benzaylideneacetophenone, diphenylacetylene, stilbazole, stilbene, diphenylacetylene, diazo and spiropyran.

37. The process of Claim 34 wherein said photoalignable top-sealing composition comprises a photoalignment polymer, oligomer or a precursor thereof represented by one of the following formulas:

Formula I



(I)

wherein x is an integer of 1-5;

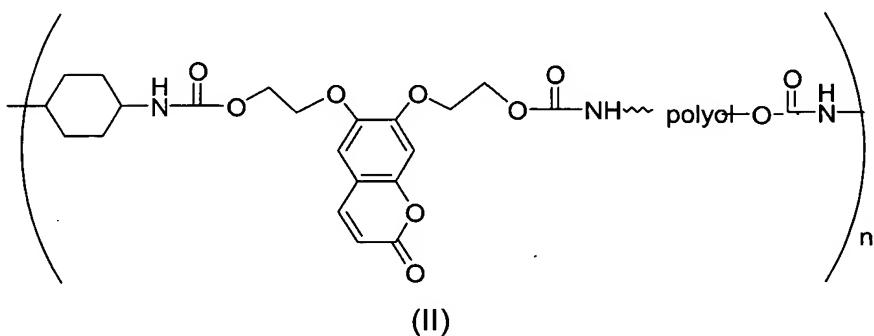
10 m and n are integers and their sum is ≥ 20 ;

R₁, R₂, R₃, R₄ and R₅ are independently alkyl, aryl, alkylaryl or their heteroatom derivatives thereof, preferably having 1-12 carbon atoms, substituted or unsubstituted alkylsilyl derivatives; and

R' is a linking group such as alkylene, cycloalkylene or phenylene;

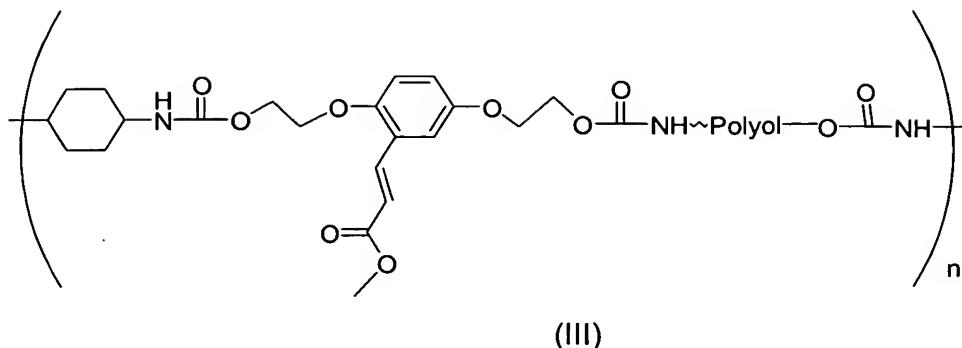
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Formula II



20 wherein n is integer ≥ 1 ; and the polyol moiety is formed from polyethylene glycol, polypropylene glycol, poly tetramethylene glycol, polyester diol, polyalkylene diol or a fluorinated polyether diol;

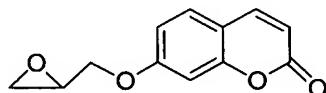
Formula III



(III)

5 wherein n is an integer ≥ 1 ; and the polyol moiety is formed from polyethylene glycol, polypropylene glycol, poly tetramethylene glycol, polyester diol, polyalkylene diol or a fluorinated polyether diol;

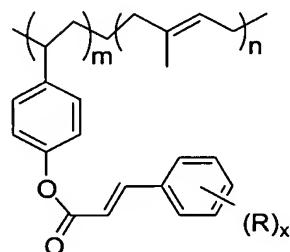
Formula IV



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(IV)

Formula V



(V)

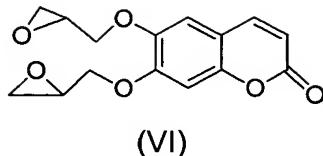
wherein x is an integer from 0 to 5;

15 m and n are integers and their sum is ≥ 30 ; and

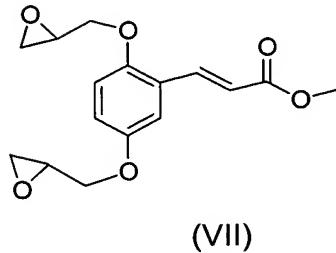
R is alkyl, aryl, alkylaryl, alkoxy, aryloxy, dialkylamino, diarylamino or cyano, preferably having 1-12 carbon atoms;

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Formula VI



5 **Formula VII**



38. The process of Claim 34 wherein hardening of the photoalignable top-
10 sealing layer may be accomplished by heat, moisture, solvent evaporation or
exposure to radiation.

39. The process of Claim 38 wherein said radiation is a polarized (UV)
light.

40. The process of Claim 27 or 34 wherein said photoalignable top-sealing
15 composition is immiscible with the liquid crystal composition.

41. The process of Claim 27 or 34 wherein said photoalignable top-sealing
composition has a specific gravity no greater than that of the liquid crystal
composition.

42. The process of Claim 27 or 34 wherein said photoalignable top-sealing
20 composition comprising a solvent that is immiscible with the liquid crystal
composition.

43. The process of Claim 27 or 34 wherein said photoalignable top-sealing
composition further comprises a non-photoalignable polymer or an additive.

44. The process of Claim 27 wherein the predispersion is prepared by an
25 in-line blender.

45. An assembly process for the manufacture of a liquid crystal display, which process comprises the following steps, not necessarily in the order listed:

- (a) optionally adding a first alignment layer over a substrate or electrode layer;
- 5 (b) aligning the alignment layer, if present;
- (c) building edge walls to define the display periphery on the alignment layer or substrate;
- (d) building spacers on the alignment layer or the substrate;
- (e) filling the display cell with a predispersion of a liquid crystal composition
- 10 and a photoalignable top-sealing composition;
- (f) hardening the sealing composition;
- (g) aligning the photoalignable top-sealing layer formed thereon by a polarized light; and
- (h) disposing a second substrate or electrode layer over the sealed display
- 15 cell, optionally with an adhesive.

46. The process of Claim 45 wherein said spacers and edge walls are built on the bottom substrate by printing, coating or photolithography.

47. The process of Claim 45 wherein said spacers and edge walls are built on the bottom substrate by photolithography.

20 48. The process of Claim 45 wherein steps (f) and (g) may be carried out simultaneously or sequentially.

49. The process of Claim 45 wherein the alignment step (b) for the first alignment layer of (a) if present may be carried out by a polarized light after the step (c) or step (d).

25 50. An assembly process for the manufacture of a liquid crystal display, which process comprises the following steps, not necessarily in the order listed:

- (a) optionally adding a first alignment layer over a substrate or electrode layer;
- (b) aligning the alignment layer, if present;
- 30 (c) building edge walls to define the display periphery;

(d) building spacers on the alignment layer or the substrate;

(e) filling the display cell with a liquid crystal composition;

(f) overcoating the filled display cells with a photoalignable top-sealing layer;

5 (g) hardening the photoalignable top-sealing layer;

(h) aligning the photoalignable top-sealing layer by a polarized light; and

(i) disposing a second substrate or electrode layer over the top-sealed display cells, optionally with an adhesive.

51. The process of Claim 50 wherein said spacers and edge walls are built
10 on the bottom substrate by printing, coating or photolithography.

52. The process of Claim 50 wherein said spacers and edge walls are built on the bottom substrate by photolithography.

53. The process of Claim 50 wherein steps (g) and (h) may be carried out simultaneously or sequentially.

15 54. The process of Claim 50 wherein the alignment step (b) for the first alignment layer of (a) if present may be carried out by a polarized light after the step (c) or step (d).

55. The process of Claim 45 or 50 wherein said second substrate or electrode layer is disposed on the top-sealed display cell by lamination, coating, printing, vapor deposition, sputtering or a combination thereof.

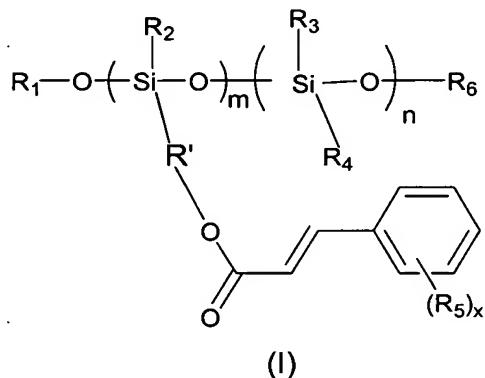
56. The process of Claim 45 or 50 wherein said adhesive of the step (h) or (i) respectively is photoalignable or self-alignable.

57. The process of Claim 45 or 50 which is carried out on a web or conveyor continuously or semi-continuously.

25 58. A liquid crystal display panel comprising display cells formed on a bottom substrate, filled with a liquid crystal composition and top-sealed by a photoalignable top-sealing layer before a top substrate is applied onto the display panel.

59. The display panel of Claim 58 wherein said photoalignable top-sealing layer is formed from a composition comprising a photoalignable polymer, oligomer or a precursor thereof represented by one of the following formulas:

5 **Formula I**



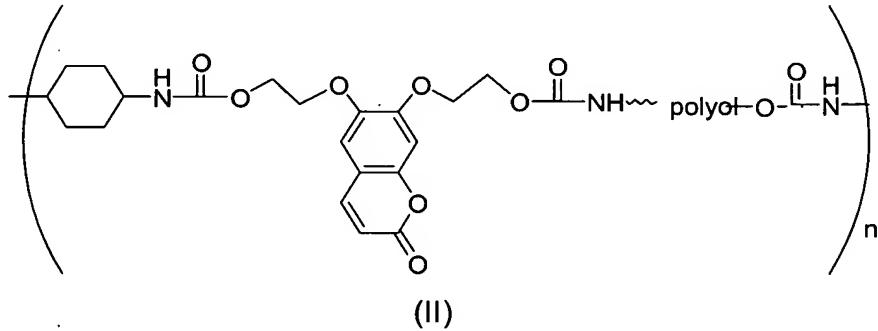
wherein x is an integer of 1-5;

m and n are integers and their sum is ≥ 20 ;

10 R₁, R₂, R₃, R₄ and R₅ are independently alkyl, aryl, alkylaryl or their heteroatom derivatives thereof, preferably having 1-12 carbon atoms, substituted or unsubstituted alkylsilyl derivatives; and
R' is a linking group such as alkylene, cycloalkylene or phenylene;

Formula II

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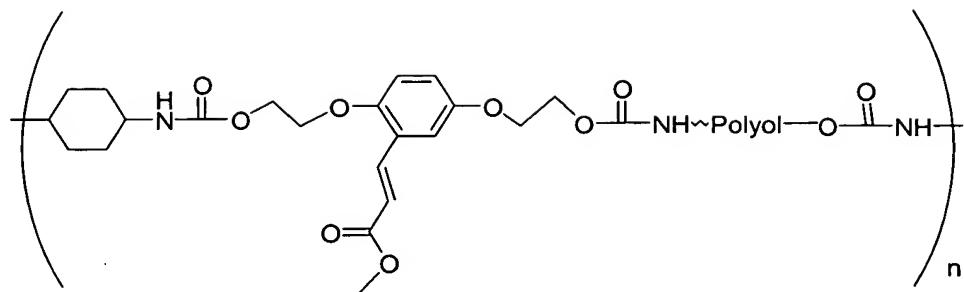


wherein n is integer ≥ 1 ; and the polyol moiety is formed from polyethylene glycol, polypropylene glycol, poly tetramethylene glycol, polyester diol, polyalkylene diol or a fluorinated polyether diol;

Formula III

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(III)

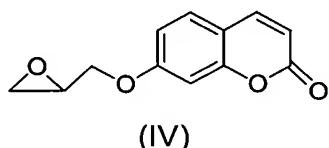


wherein n is an integer ≥ 1 ; and the polyol moiety is formed from polyethylene glycol, polypropylene glycol, poly tetramethylene glycol, polyester diol, polyalkylene diol or a fluorinated polyether diol;

Formula IV

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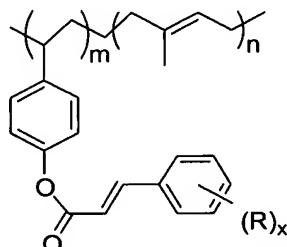
(IV)



Formula V

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(V)



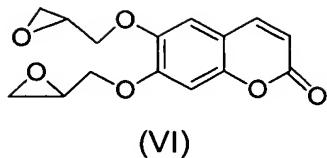
wherein x is an integer from 0 to 5;

m and n are integers and their sum is ≥ 30 ; and

R is alkyl, aryl, alkylaryl, alkoxy, aryloxy, dialkylamino, diarylamino or cyano,

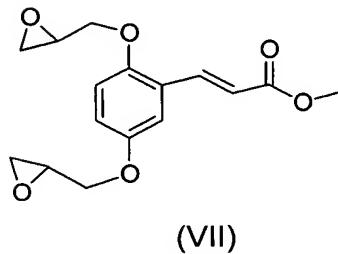
20 preferably having 1-12 carbon atoms;

Formula VI



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Formula VII



10 60. The display panel of Claim 58 wherein said photoalignable top-sealing layer comprises a photoalignable polymer, oligomer or a precursor thereof comprising a functional group selected from the group consisting of cinnamate, coumarin, chalcony, benzolidenenaphthalidine, benzylideneacetophenone, diphenylacetylene, stilbazole, stilbene, diphenylacetylene, diazo and spiropyran.

15 61. A liquid crystal display panel comprising display cells each of said display cells comprises:

- a) spacers or edge walls;
- b) a liquid crystal composition filled therein, and
- c) a photoalignable sealing layer which encloses the liquid crystal

20 composition within each cell.

62. The liquid crystal display panel of Claim 61 wherein said photoalignable sealing layer is in contact with the inside surface of the spacers or edge walls.

25 63. The liquid crystal panel of Claim 62 wherein there is a wetting curvature at the interface between the spacers or edge walls and the top-sealing photoalignment layer.

64. The liquid crystal panel of Claim 61 wherein said photoalignable sealing layer has a thickness in the range of about 1 to about 20 microns.

65. The liquid crystal panel of Claim 61 wherein said photoalignable sealing layer has a thickness in the range of about 1 to about 8 microns.

5 66. The liquid crystal panel of Claim 61 wherein said photoalignable sealing layer has a thickness in the range of about 2 to about 4 microns.